Plasma Phospholipid Fatty Acids in the Central Canadian Arctic: Biocultural Explanations for Ethnic Differences

T. KUE YOUNG,[1]* JON M. GERRARD,[2] AND JOHN D. O'NEIL[1]
[1]*Department of Community Health Sciences, University of Manitoba, Winnipeg, Manitoba, Canada*
[2]*Department of Pediatrics and Child Health, University of Manitoba, Winnipeg, Manitoba, Canada*

KEY WORDS Canada; Arctic; Inuit; fatty acids; lipid metabolism; nutrition

ABSRACT As part of the Keewatin Health Assessment Study, a comprehensive health interview and examination survey of Inuit and non-Inuit in the central Canadian Arctic during 1990–91, plasma samples were analyzed for phospholipid fatty acid composition. Compared to non-Inuit, the Inuit have reduced levels of dihomo-gamma-linoleic (DGLA) and arachidonic acid (ratios of 0.41 and 0.46) and the sum of all n-6 fatty acids (ratio of 0.65), but increased level of eicosapentaenoic (EPA) acid (ratio of 1.37). These trends are consistent with those reported from other circumpolar Inuit populations, especially the reduced arachidonic acid and increased EPA, although the Inuit excess in EPA is much less pronounced due to the greater importance of caribou rather than sea mammals in most of the Keewatin communities. The high linoleic/arachidonic acid ratio suggests increased inhibition of the metabolic pathway regulated by the enzyme Δ-5 desaturase, which can be explained by the presence of high levels of highly unsaturated fatty acids of dietary origin, and/or a genetic deficiency. In multiple linear regression models with the independent variable list consisting of Inuit status, age, sex, education, physical activity, spending time on the land and consumption of wild meat and local fish, Inuit status is independently associated with lower levels of the n-6 acids but not the n-3 acids. This indicates that factors other than diet and lifestyle, perhaps genetic ones, may account for the observed "ethnic" differences. However, for those fatty acids in which Inuit differ from non-Inuit, there is no dose-response relationship in terms of self-reported degree of non-Inuit admixture. Dietary fatty acids play an important role in the risk of cardiovascular diseases and diabetes, diseases of increasing importance in the health transition experienced by the Inuit. Association studies of plasma fatty acids and DNA markers of candidate genes for atherosclerosis and insulin resistance may provide a clearer picture of the genetic basis for the observed differences in plasma fatty acid composition between Inuit and non-Inuit. Am J Phys Anthropol 109:9–18, 1999.

Studies among the Inuit of Greenland by Dyerberg, Bang and colleagues in the 1970s and 1980s provided evidence for the association between the Inuit pattern of dietary fatty acids with prostaglandin synthesis, platelet aggregability and the risk of ischemic heart disease (Dyerberg and Bang, 1979; Jorgensen et al., 1986). Subsequent world wide interest in the role of fish oils in preventing heart disease (Kromhout, 1989) offers an excellent example of the contribution of cross-cultural studies among aborigi-

Grant support: National Health Development Program of Health Canada; Grant number: 6607-1550-T.

*Correspondence to: Dr. T. Kue Young, Department of Community Health Sciences, 750 Bannatyne Avenue, University of Manitoba, Winnipeg, MB, Canada R3E 0W3. E-mail: tkyoung@cc.umanitoba.ca

Received 14 July 1997; accepted 10 January 1999.

nal populations to the understanding of disease mechanisms.

The Greenland Inuit diet is characterized by a high ratio of polyunsaturated (PUFA) to saturated fatty acids. Of the PUFAs, those found in much higher proportions in the Inuit diet belong to the n-3 family of marine origin, such as eicosapentaenoic acid (20: 5n-3; EPA) and docosahexaenoic acid (22: 6n-3; DHA). By contrast, fatty acids of the n-6 family, such as linoleic acid (18:2n-6) and arachidonic acid (29:4n-6), are found in lower proportions compared to Europeans (Bang et al., 1980). The fatty acid composition of plasma lipids in Greenland Inuit shows a pattern similar to that found in their diet (Dyerberg et al., 1975). Similar but not identical patterns have since been observed among Inuit in other regions of the circumpolar world: Broughton Island in the eastern Canadian Arctic (Innis et al., 1988), Chukotka in Russia (Gerasimova et al., 1991) and Alaska (Parkinson et al., 1994).

The plasma fatty acid pattern of Inuit who have settled in Denmark tend to approximate that of the Danes rather than their kin who remain in Greenland (Dyerberg et al., 1975). Genetic deficiency of some of the enzymes involved in the intermediate metabolism of fatty acids has been proposed to account jointly with dietary factors for the observed differences between Danes and Greenland Inuit, and similarities between Danes and Inuit migrants in Denmark (Horrobin, 1987).

The Keewatin Health Assessment Study (KHAS), a comprehensive health interview and examination survey of a representative sample of Inuit and non-Inuit in the Keewatin region of the central Canadian Arctic, provides an opportunity to examine biological and cultural factors which may account for the observed "ethnic" differences in plasma fatty acids.

METHODS

The KHAS was conducted during 1990–91 in seven predominantly Inuit communities in the Keewatin Region of the Northwest Territories (NWT), Canada (bounded by 60°–69°N and 80°–102°W); the Inuit community of Sanikiluaq on the Belcher Islands near the eastern shore of Hudson Bay; and the predominantly non-Inuit town of Churchill in northern Manitoba just south of the 60th parallel (Fig. 1). A particular focus of the KHAS is the burden and determinants of chronic diseases among northern indigenous populations undergoing rapid social and cultural change. Studies on plasma lipids (Young et al., 1995) and obesity (Young, 1996a, 1996b) have been published to date.

A regional census was conducted prior to the study to create a sampling frame. A 20% random sample was selected, stratified by community. Overall the response rate was 71%, resulting in a final sample of 505 adults (230 men and 275 women) aged 18–74, of whom 379 were Inuit, 95 white, and 31 "other."

The survey consisted of an interviewer-administered questionnaire, clinical examination, and laboratory tests. The questionnaire sought demographic information and data on personal health and lifestyle habits. Two blood pressure measurements were taken at least 10 min apart after resting, using an appropriate cuff size of a standard mercury sphygmomanometer. Anthropometry consisted of measurements of the subscapular and triceps skinfold thicknesses, waist and hip girths, and height and weight. Venipuncture was performed on participants after overnight fasting. Plasma samples were analyzed for lipids (total cholesterol, high-density-lipoprotein, low-density-lipoprotein, and triglycerides), fatty acids, glucose and insulin levels. The technical details of these clinical and laboratory procedures have previously been described (Young et al., 1995; Young, 1996).

Plasma samples destined for fatty acid analyses were refrigerated and transported on ice to Winnipeg, where they were frozen until the analysis was performed. After warming the samples to room temperature, the lipids were extracted using a mixture of methanol and chloroform. The phospholipid fractions were separated by thin-layer chromatography and hydrolyzed. The resulting fatty acids were methylated with boron trifluoride. The fatty acid methyl esters were then analyzed by gas-liquid chromatography (HP5890 Series II Gas Chromatograph

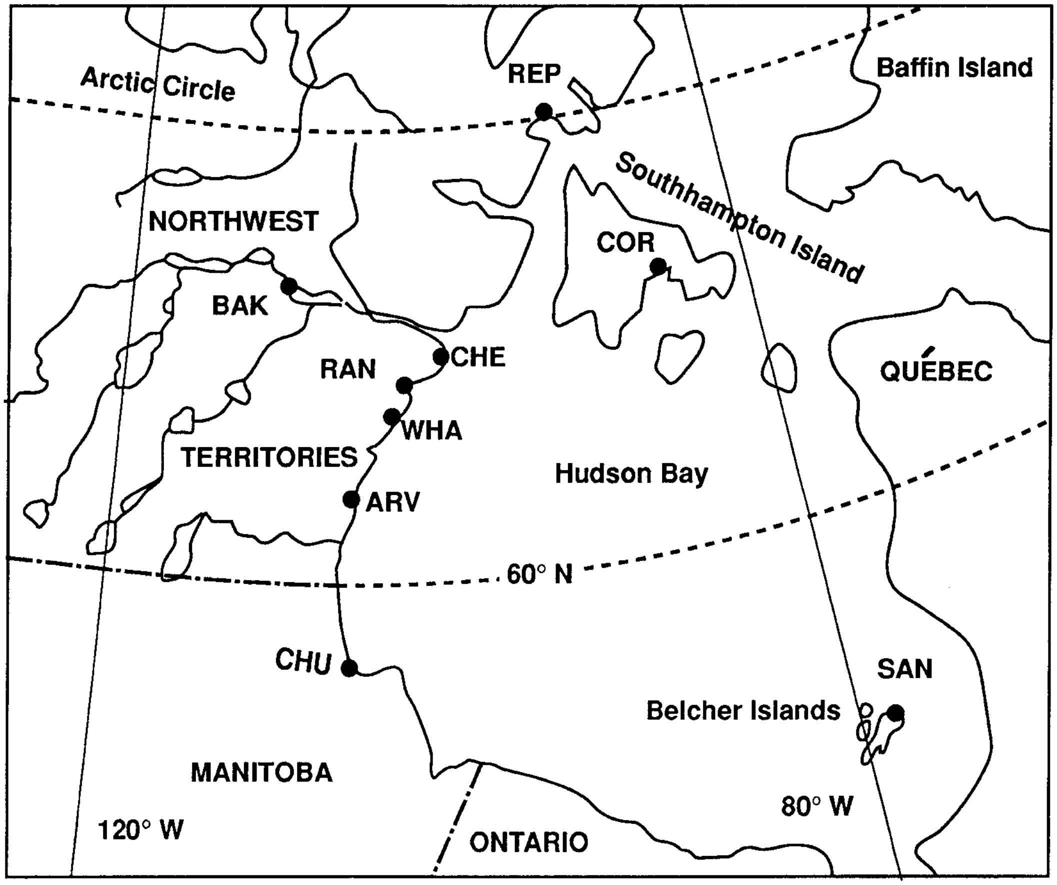

Fig. 1. Map showing communities participating in the Keewatin Health Assessment Study. ARV, Arviat; BAK, Baker Lake; CHE, Chesterfield Inlet; CHU, Churchill; COR, Coral Harbour; RAN, Rankin Inlet; REP, Repulse Bay; SAN, Sanikiluaq; WHA, Whale Cove.

and the HPCHEM computer software, Hewlett-Packard Canada Ltd., Toronto). These methods were used in previous studies and reported (Hornstra et al., 1992; Popeski et al., 1991).

In this paper, an abbreviated, structural nomenclature of fatty acids is used. For example, 20:5n-3 refers to a fatty acid with chain length of 20 (eicosa-) carbon atoms and five (penta-) double bonds, the first one of which is located at the third carbon atom from the terminal methyl carbon (hence n-3, also referred to as ω-3). The formal, systematic name is 5,8,11,14,17-eicosapentaenoic acid, where the numbers refer to the location of the five double bonds, but counted from the carboxyl end. This name is abbreviated to eicosapentaenoic acid, or EPA. Many economically important fatty acids also have better known, trivial names (e.g., palmitic, oleic, linoleic, and arachidonic acids). Unless specified as cis or trans, all fatty acids have the cis configuration of the alkyl groups in the double bond. Chain lengths with 19 or more carbon atoms are considered as long. Saturated fatty acids (SFA) contain no double bonds (e.g., 16:0, palmitic acid; 18:0, stearic acid). Monounsaturated fatty acids (MUFA) contain one double bond (e.g., cis-18:1n-9, oleic acid; trans-18:1n-9, elaidic acid), while polyunsaturated fatty acids (PUFA) contain two or more double bonds (e.g., 18:2n-6, linoleic acid; 18:3n-3, alpha-linolenic acid; 22:6n-3, docosahexaenoic acid). Those with

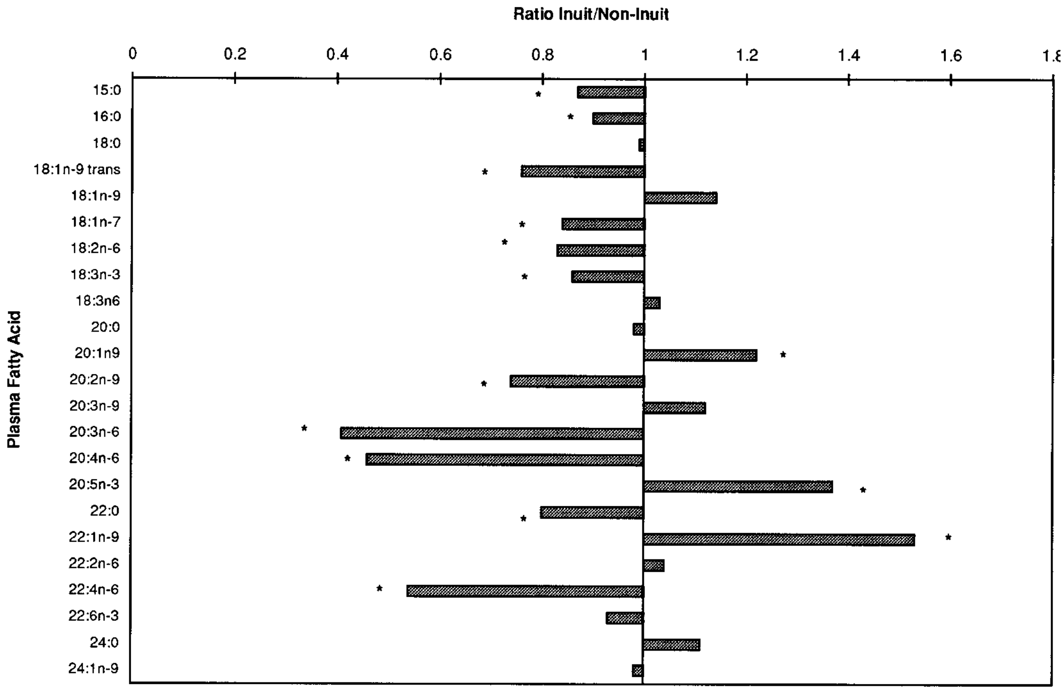

Fig. 2. Inuit/non-Inuit ratios for selected individual plasma fatty acids. An asterisk accompanies each bar representing an Inuit/non-Inuit ratio which differs significantly ($P < 0.05$) from unity.

four or more double bonds are considered highly unsaturated (HUFA).

RESULTS

Fatty acid values were available for 319 individuals. Due to their skewness and kurtosis, the data were logarithm-transformed in statistical analyses. The ratios of individual fatty acid values and various indices between Inuit and non-Inuit are shown graphically in Figures 2 and 3. The ratio of two means (and its 95% confidence interval, CI) is obtained by exponentiating the difference between two log-transformed means (and its 95% CI). Compared to non-Inuit, Inuit have less than half the level of dihomo-gamma-linolenic acid (20:3n-6, DGLA) and arachidonic acid (20:4n-6), with ratios of 0.41 (95% CI: 0.30–0.55) and 0.46 (95% CI: 0.40–0.53) respectively. On the other hand, higher levels of EPA are found among the Inuit (Inuit/non-Inuit ratio 1.37, 95% CI: 1.02–1.85). Overall the level of PUFAs is lower among the Inuit than non-Inuit (ratio 0.71, 95% CI: 0.64–0.79), due mainly to the lower level of n-6 fatty acids (ratio 0.65, 95% CI: 0.58–0.73). For MUFAs and SFAs, there is no significant difference between Inuit and non-Inuit.

Inuit, however, differ from non-Inuit in many sociocultural and behavioral attributes (Table 1). Inuit are less likely to have completed secondary schooling, to be employed full-time, or earn more than $10,000 per year. The non-Inuit sample consists of northerners living in the same region, many of whom also engage in outdoors activities. It is therefore not surprising that the pattern of physical activity and also the frequency of spending some time “on the land” do not differ significantly between Inuit and non-Inuit ($P > 0.05$). Inuit, however, have greater access to country foods, and wild meats and local fish constitute a higher proportion of the diet of Inuit than non-Inuit. We also compare Inuit who considered themselves as full heritage and those with only partial Inuit heritage. While full-heritage Inuit are on the average 5 years older, the two groups do not differ in terms of the distribution of

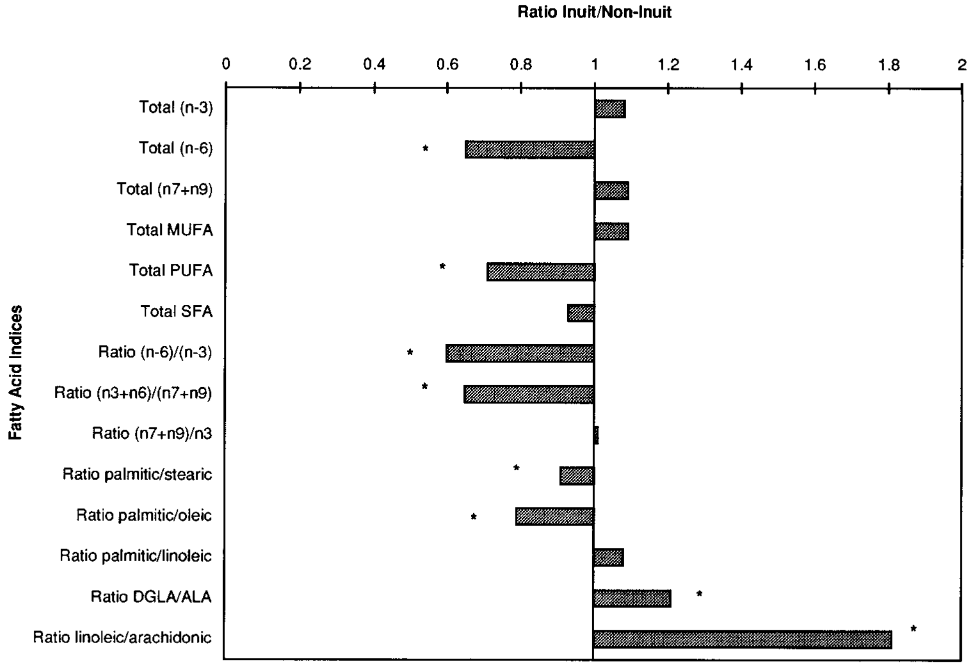

Fig. 3. Inuit/non-Inuit ratios for selected plasma fatty acid indices. An asterisk accompanies each bar representing an Inuit/non-Inuit ratio which differs significantly ($P < 0.05$) from unity.

the major socioeconomic, cultural and behavioral variables, with the exception of the consumption of meat obtained from the land. A higher proportion of full-heritage Inuit obtained 75% or more of their meat from the land. It should be noted that among the full-heritage group, there may well have been European admixture several generations back unbeknownst to the respondent.

Age is correlated with some fatty acids but not with others. The level of the n-3 group of PUFA increases with age ($r = 0.40$, $P < 0.01$); within this group, EPA and DHA are also correlated with age ($r = 0.37$, 0.40 respectively, $P < 0.01$). The n-6 group of PUFAs is not correlated with age ($r = -0.06$, $P > 0.01$); within this group, linoleic acid decreases with age ($r = -0.16$, $P < 0.01$) whereas arachidonic acid increases with age ($r = 0.28$, $P < 0.01$).

To determine if various fatty acid indices still differ according to Inuit status, after controlling for various demographic, sociocultural, behavioral and dietary factors, we performed multiple regression analyses, with an independent variable list consisting of Inuit status, age, sex, education, physical activity, spending time on the land, and consuming wild meat and local fish. Table 2 shows that Inuit status (1 = Inuit, 0 = non-Inuit) is associated with lower levels of palmitic, linoleic, DGLA, arachidonic and adrenic acids (i.e., with a negative standardized coefficient); whereas for stearic, α-linolenic, γ-linolenic, EPA and DHA, Inuit status is not an independent determinant when age and other cultural and behavioral variables have been controlled for.

We performed similar regression analyses among Inuit only and found that the degree of Inuit ancestry (full vs. partial-heritage) failed to account for any difference in fatty acid indices after controlling for a similar list of independent variables but including the ability to speak Inuktitut fluently as a measure of "traditionality."

DISCUSSION

Our study shows that Inuit differ from non-Inuit in terms of the distribution of various plasma fatty acids. Most notably, the Inuit have lower levels of arachidonic

TABLE 1. Comparison of sociocultural characteristics between Inuit and non-Inuit, and between full and partial-heritage Inuit

	Non-Inuit	Inuit	*P*	Full-heritage	Partial-heritage	*P*
Mean age (years)	36.86	36.91	0.971	38.2	33.9	0.012
Physical exertion in daily activities						
Vigorous	15.7	17.6	0.082	19.7	13.3	0.340
Moderate	52.1	60.5		58.3	65.3	
Inactive	32.2	21.7		22.0	21.4	
Highest level of education						
Primary only	8.9	53.0	0.000	56.3	45.9	0.068
Some secondary	91.1	47.0		43.7	54.1	
Employment past year						
Unemployed	13.1	55.2	0.000	59.1	46.8	0.092
Part-time/casual	12.3	16.6		15.0	20.7	
Full-time	74.6	28.3		26.0	32.4	
Personal income past year						
<$10,000	16.8	44.3	0.000	46.1	41.4	0.218
>$10,000	79.8	23.6		20.5	28.8	
Not stated	3.4	32.1		33.5	29.7	
Fluency in speaking Inuktitut						
Not fluent	96.7	24.2	0.000	22.4	27.9	0.260
Fluent	3.3	75.8		77.6	72.1	
No. of times spent on the land during the spring/summer						
1+/week	42.9	55.0	0.070	55.0	54.6	0.877
1–3/month	34.4	26.2		25.6	27.8	
<1/month	22.7	18.8		19.6	17.6	
No. of times spent on the land during the fall/winter						
1+/week	26.7	23.7	0.344	22.9	25.2	0.887
1–3/month	30.0	25.3		25.8	24.3	
<1/month	43.3	51.0		51.3	50.5	
Proportion of meat in diet obtained from the wild						
<25%	81.6	21.9	0.000	18.0	30.6	0.027
~50%	10.3	25.6		26.5	23.4	
75%+	8.1	52.5		55.5	45.9	
Proportion of fish in diet obtained in local waters						
<25%	63.0	30.1	0.000	29.0	32.4	0.377
~50%	5.9	14.6		16.3	10.8	
75%+	31.1	55.3		54.7	56.8	

P values based on chi-square for comparing categories and *t*-test for comparing means.

acid and DGLA, but higher EPA. Table 3 compares the Inuit/non-Inuit ratios from our study with several other studies involving the Inuit. (Note that in the Chukotka study, data from the Inuit are combined with those of the Chukchi, the major aboriginal group in the region.) There is consistency with regards to the lower arachidonic acid and higher EPA. The lower DGLA level among Inuit is observed in northern Canada and Alaska but not in Greenland. EPA is only 40% higher among Inuit in our study, substantially less than the 14-fold and 44-fold increase among coastal Alaskans and Greenlanders. This is partly the result of dietary differences between the various Inuit groups, e.g., the relative importance of fish, marine mammals and land mammals, which differ in the fatty acid composition (Innis and Kuhnlein, 1987). In the Keewatin region, the main traditional meat is caribou, which contains much less EPA than fish or meat from marine mammals. Seal and walrus are important meat sources in Coral Harbour on Southampton Island and Sanikiluaq on Belchers Island. Indeed, these two communities have the highest EPA and DHA concentrations. Furthermore, the comparison non-Inuit group in our study consists of northerners who share many lifestyles and a similar environment with the Inuit. In the other studies the non-Inuit were recruited from urban dwellers in Vancouver, Oregon, Denmark and Moscow. With the exception of

TABLE 2. Summary of regression analyses: standardized regression coefficients of independent variables predicting fatty acid levels and indices

		Independent variables				
Fatty acids	Model R2	Inuit status	Age	Physical activity	Time on the land	Country foods
16:0 (palmitic)	0.135	−0.143	0.212	0.192	0.154	—
18:0 (stearic)	0.101	—	0.245	0.123	0.164	—
18:2n-6 (linoleic)	0.103	−0.186	−0.198	0.186	0.148	—
18:3n-3 (alpha-linolenic)	0.092	—	—	0.142	0.204	−0.147
20:3n-6 (DGLA)	0.140	−0.302	—	—	0.194	—
20:4n-6 (arachidonic)	0.402	−0.569	0.250	—	—	—
20:5n-3 (EPA)	0.239	—	0.445	—	—	0.137
22:4n-6 (adrenic)	0.321	−0.433	—	—	0.193	−0.168
22:6n-3 (DHA)	0.232	—	0.469	0.116	—	—
Total n-3	0.263	—	0.513	—	—	—
Total n-6	0.238	−0.402	—	0.156	0.179	—
Ratio n-6/n-3	0.333	−0.245	−0.508	—	0.155	—
Total MUFA	0.064	—	—	0.144	0.145	—
Total PUFA	0.197	−0.360	—	0.158	0.161	—
Total SFA	0.126	—	0.246	0.190	—	—

All regression models in the table are significant ($P < 0.05$). Only significant coefficients ($P < 0.001$ in all cases) are shown in the table; dashes represent non-significant coefficients.

TABLE 3. Comparison of studies showing Inuit/non-Inuit ratios of plasma fatty acids

	Keewatin, Canada	Broughton Island, Canada		Alaska, USA		Greenland		Chukotka, Russia
		Male	Female	Coast	River	In GL	In DK	
Inuit adult sample size	232	55	72	20	20	130	32	261
16:0 (palmitic)	0.9	1.4	1.9	0.8	0.8	1.1	1.1	1.1
18:0 (stearic)	1.0	0.8	0.8	1.2	1.2	1.1	0.9	0.8
18:2n-6 (linoleic)	0.8	1.0	0.8	0.9	1.1	0.3	1.1	0.6
18:3n-3 (alpha-linolenic)	0.9	4.7	4.0	0.7	0.9			
18:3n-6 (gamma-linolenic)	1.0	0.3	0.5	0.4	0.6			
20:3n-6 (DGLA)	0.4	0.3	0.4	0.4	0.5	1.2	1.9	
20:4n-6 (arachidonic)	0.5	0.6	0.5	0.4	0.7	0.1	0.2	0.4
20:5n-3 (EPA)	1.4	4.4	1.8	13.9	6.6	44.4	4.6	2.8
22:6n-3 (DHA)	0.9	1.5	1.3	3.5	2.7	1.3	0.3	1.1
Total n-3	1.1	1.6	1.6	4.2	2.7			
Total n-6	0.7	0.5	0.4	0.9	1.0			
Ratio n-6/n-3	0.6	0.3	0.3	0.3	4.0			
Total MUFA	0.9					1.2	1.1	
Total PUFA	1.1					1.2	1.1	
Total SFA	0.7					0.6	0.9	
Non-Inuit comparison group	Northerners (n = 78)	Vancouver (n = 12M, 12F)		Oregon (n = 13)		Danes in Denmark (n = 31)		Moscow (n = 650)

In GL = Greenland Inuit living in Greenland; in DK = Greenland Inuit living in Denmark.

the Chukotka study, the other studies involved smaller sample sizes than ours and can be expected to yield less stable and precise estimates.

The low level of arachidonic acid in all Arctic populations suggests the inhibition of the conversion of linoleic (18:2n-6) to arachidonic (20:4n-6) acid. The chain of metabolic reactions is regulated by Δ-6 and Δ-5 desaturases, which increase the number of double bonds, and elongases, which add carbon atoms, thus at the end resulting in longer chain, highly unsaturated fatty acids (HUFA):

$$18{:}2\text{n-}6 \xrightarrow{(\Delta\text{-}6)} 18{:}3\text{n-}6 \xrightarrow{\text{elongase}} 20{:}3\text{n-}6$$

$$\xrightarrow{(\Delta\text{-}5)} 20{:}4\text{n-}6 \xrightarrow{\text{elongase}} 22{:}4\text{n-}6 \xrightarrow{(\Delta\text{-}4)} 22{:}5\text{n-}6$$

There are parallel pathways involving the n-3, n-7 and n-9 series (Nelson, 1992:447):

$$18{:}3\text{n-}3 \xrightarrow{(\Delta\text{-}6)} 18{:}4\text{n-}3 \xrightarrow{\text{elongase}} 20{:}4\text{n-}3$$

$$\xrightarrow{(\Delta\text{-}5)} 20{:}5\text{n-}3 \xrightarrow{\text{elongase}} 22{:}5\text{n-}3 \xrightarrow{(\Delta\text{-}4)} 22{:}6\text{n-}3$$

$$16{:}\text{ln-}7 \xrightarrow{(\Delta\text{-}6)} 16{:}2\text{n-}7 \xrightarrow{\text{elongase}} 18{:}2\text{n-}7 \xrightarrow{(\Delta\text{-}5)} 18{:}3\text{n-}7$$

$$18{:}\text{ln-}9 \xrightarrow{(\Delta\text{-}6)} 18{:}2\text{n-}9 \xrightarrow{\text{elongase}} 20{:}2\text{n-}9$$

$$\xrightarrow{(\Delta\text{-}5)} 20{:}3\text{n-}9 \xrightarrow{\text{elongase}} 22{:}3\text{n-}9$$

There is no interconversion between the different series, except between the n-7 and n-9 series, where 16:1n7 (palmitoleic) can be converted to 18:1n9 (oleic). Linoleic (18:2n6) and α-linolenic (18:3n-3) acids cannot be synthesized in the body and must be obtained in the diet, and are hence called essential fatty acids (EFA).

The action of Δ-6 desaturase is regulated by feedback inhibition by the highly unsaturated end-products of the same series (e.g., arachidonic acid inhibiting linoleic acid) and also competitive inhibition by HUFAs of another series (e.g., EPA inhibiting linoleic acid). The degree of inhibition can be seen from the linoleic/arachidonic acid ratio. In our study, this ratio is almost twice as high in the Inuit than in the non-Inuit (Fig. 3). While the increased inhibition can be explained in terms of the higher dietary intake of EPA and other n-3 PUFA of marine origin, Horrobin (1987) suggested that the Inuit may also have a genetic deficiency of Δ-5 desaturase based on a re-examination of Dyerberg's data on Inuit in Greenland and Denmark (Dyerberg et al., 1975). When changing from a traditional to a Danish diet, Inuit who have migrated to Denmark continue to have low arachidonic acid while DGLA level remains high. However, the Greenland data are not corroborated by data from other Inuit populations (Table 3), as they all show low DGLA levels.

In our regression analyses, we observed that Inuit status remains a significant independent determinant of linoleic, DGLA, arachidonic and adrenic acid—the entire n-6 series—even when dietary and lifestyle factors have been taken into account. EPA and DHA, on the other hand, are not independently associated with Inuit status, but rather with age, physical activity level, time spent on the land and consumption of country foods. This finding suggests that there may well be a genetic basis for the observed Inuit/non-Inuit differences, as more obvious cultural, environmental and behavioral factors have been accounted for. While we are unable to show any "dose-response" relationship (i.e., with the degree of Inuit heritage) in these fatty acids, the validity of self-report of a totally non-admixed ancestry is difficult to establish. Moreover, one cannot discount the role of genetics. As independent loci assort independently, there is no reason to assume that European markers after admixture will continue to be linked with the putative genetic system that controls the relevant fatty acid patterns.

The Inuit have lower levels of both EFAs (Fig. 2). For linoleic acid (18:2n-6), the Inuit/non-Inuit ratio is 0.83 (95% CI: 0.74–0.94) and for α-linolenic acid (18:3n-3) the ratio is 0.86 (95% CI: 0.74–0.99). Plant oilseeds such as maize, soybeans, and safflower are a major source of linoleic acid and leafy vegetables a source of α-linolenic acid, and none of these foods are significant items in the contemporary Inuit diet. A measure of EFA status is the ratio of total n-3 + n-6 to total n-7 + n-9, as deficiency in linoleic and α-linolenic acid would depress the entire n-3 and n-6 series. The EFA status index is lower among Inuit than non-Inuit (ratio 0.65, 95% CI: 0.60–0.70). In the absence of dietary EFA, the enzymes that desaturate linoleic and α-linolenic acid will desaturate eicosenoic (20:1n-9, or gadoleic) acid to produce eicosatrienoic (20:3n-9, or Mead) acid. The ratio of Mead acid to arachidonic acid serves as an index of EFA deficiency. Inuit have more than double the value of the EFA deficiency index than non-Inuit (ratio 2.34, 95% CI: 1.93–2.84).

Our data can be compared to umbilical cord blood data on Inuit and Dutch neonates using the same laboratory methods (Hornstra et al., 1992). Among neonates, the Inuit/non-Inuit ratios tend to be the reverse of

those seen in adults in our study. In neonates, linoleic acid and DGLA are high among the Inuit, while arachidonic acid is low, indicating the reduced conversion of DGLA to arachidonic acid, a reaction mediated by Δ-5. This is the situation seen in Greenland and used by Horrobin as evidence of a genetic deficiency of Δ-5 desaturase. Low Δ-5 activity may also be responsible for the unexpectedly low EPA and DHA levels seen in Inuit neonates. This pattern is observed despite the high maternal dietary intake of n-3 PUFAs, especially EPA, and their high level in breast milk (Innis and Kuhnlein, 1988). Yet, one should not expect to see a genetically determined enzyme deficiency to disappear as an individual ages.

The data in our study cannot confirm or negate the evidence for a genetic basis in the different fatty acid patterns between Inuit and non-Inuit. In a recent study comparing the frequency of various DNA markers of candidate genes for an atherogenic lipid profile and insulin resistance between the Keewatin Inuit and northern whites, the Inuit are found to have a high frequency of the T54 allele of the gene encoding the intestinal fatty acid binding protein (FABP2) (Hegele et al., 1997). FABP2 is one of a family of intracellular lipid binding proteins which plays a role in the absorption and intracellular transport of dietary long chain fatty acids (Sweetser et al., 1987). An association of the T54 allele with plasma levels of fatty acids will strengthen the arguments for a genetic basis of the observed Inuit/non-Inuit difference in fatty acid composition. This issue has important public health implications. As more western foods (generally linoleic acid based–vegetables, cooking oils, margarines, etc.) are introduced, these foods will provide the linoleic acid but not the arachidonic acid, if the conversion is genetically inhibited. With reduced consumption of the traditional foods, dietary intake of arachidonic and EPA will also be curtailed.

Dietary fatty acids are important factors in the health transition that the Inuit and other Aboriginal groups are undergoing, characterized by the emergence of chronic diseases such as ischemic heart disease and diabetes (Bjerregaard and Young, 1998; Young, 1994). There is a substantial literature from both laboratory and epidemiologic studies on the strong effect of dietary fatty acids on plasma lipid and lipoprotein profiles and hence cardiovascular disease risk (Caggiula and Mustad, 1997). A study from Alaska has also shown that individuals who consume seal oil and salmon daily (hence have higher intake of EPA and other n-3 PUFAs) have reduced risk of glucose intolerance and diabetes mellitus (Adler et al., 1994). The study of the biological and cultural correlates of fatty acid is thus key to an understanding of the determinants of health among the Inuit and suggest potential interventions to control chronic diseases and improve the population's health.

There is increasing evidence that fatty acids can directly influence the expression of genes in fatty acid metabolism through their activation of the peroxisome proliferator-activated receptor (PPAR) family of nuclear hormone receptors (Lemberger et al., 1996). Dietary fatty acids and genetic variation at specific loci could interact to mediate lipid homeostasis and risk of metabolic disorders such as insulin resistance, obesity, and diabetes. The modulation of gene expression provides a long-term mechanism that adjusts the synthesis of new gene products suitable to the changing metabolic needs and indeed survival of the organism. This study attests to the continuing scientific value of research among the Inuit and other indigenous peoples which contributes to our understanding of the causation, mechanism and distribution of diseases affecting the entire human species.

ACKNOWLEDGMENTS

The Keewatin Health Assessment Study was funded by the National Health Development Program of Health Canada (6607-1550-T). Dr. Young is recipient of the Senior Scientist award of the Medical Research Council of Canada. The cooperation and assistance provided by the Keewatin Regional Health Board is gratefully acknowledged.

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